MECHANICAL APTITUDE V

INDIVIDUAL AND GROUP TESTS OF MECHANICAL APTITUDE

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Under Contract with the Office of Naval Research
~~Project~~ N6ori-20, Task ~~Order~~ 12
~~ONR~~ Project ~~No.~~ NR 151-039

THE PSYCHOMETRIC LABO~~RATORY~~
~~THE~~ UNIVER~~SITY~~ OF CHICAGO

NUMBER 57

MAY, 1950

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This paper is one of several reports on the experimental work on mechanical aptitude that has been done in the Psychometric Laboratory in the last couple of years. There were twenty-five individual tests and thirty-two group tests in this study. The tests were selected to represent current ideas about mechanical aptitude as well as a number of psychological hypotheses about the nature of these mental abilities. The analysis of the present paper deals with a comparison of two groups of boys in the Tilden High School in Chicago. A total group of 350 technical high school students were given the thirty-two group tests. In addition to the group tests these students were also given an interest schedule, a test of mechanical experience representing tool knowledge, and a test called mechanical comprehension. These three measures constituted an informal criterion for mechanical interest, mechanical aptitude, and mechanical experience. One group of forty-five boys was selected who showed exceptional mechanical interest and who had good scores on tests of mechanical experience. In the Kuder Schedule, for example, we chose for this group only those boys whose mechanical interests were definitely higher than all the other interests in the Kuder Schedule. The low mechanical interest group was selected in the same manner. It consisted of forty-five boys who had exceptionally low mechanical interest, poor performance in tests of tool knowledge and mechanical experience, and poor performance in tests of mechanical comprehension. These two groups constituted about one-fourth of the total experimental population in Tilden High School. One of the problems was to compare these two groups of subjects who represented high and low mechanical interest and aptitude. The comparison was made separately for each of the thirty-two group tests and also for each of twenty-five individual tests which were given to these selected groups of students. The same data were used for factorial analyses of mechanical aptitude, but those studies are summarized in other reports.[1]

The selection of the tests which should represent mechanical aptitude was done with several considerations in mind. Many of the current tests that pretend to estimate mechanical aptitude call for little more than finger dexterity, and manipulatory speed or skill. We included a number of tests of this character even though we do not believe that such tests represent mechanical aptitude. Another consideration was the concept of mechanical aptitude as representing essential intellectual functions. Such interpretations of mechanical aptitude are represented by those tests in which the subject's success or failure depends on his ability to use his head on mechanical problems. A criterion could, of course, be set up so as to represent either manipulatory speed and dexterity or the ability to think about mechanical relations.

A criterion could be designed formally as a linear combination of the three criterion measures, but we preferred to select the high and low interest groups in an informal manner. The criterion can be designated as a mere sum of the three criterion test scores. Such a variable is represented on the base line of Figure 1. On this base line we have represented the total population as a histogram. The high and low mechanical interest groups are also represented

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*Prepared in connection with research sponsored by the Office of Naval Research, Project N6ori-20, Task Order 12, ONR Project No. NR 151-039. The writer wishes to acknowledge the assistance of Mr. Thomas Jeffrey who was responsible for the computing in this study.

1. The other parts in this study have also been prepared as Psychometric Laboratory reports as follows: Number 54, Mechanical Aptitude II, Description of Group Tests; Number 55, Mechanical Aptitude III, Analysis of Group Tests; Number 56, Mechanical Aptitude IV, Description of Individual Tests. These reports will be submitted for publication in psychological journals.

in Figure 1. The findings are summarized in several tables. In Table 1 are listed the twenty-five individual tests[2] together with the principal information about each test, including the number of cases in the two groups, the two group means, the two dispersions, and the t-value. These values indicate the relative effectiveness with which the tests and schedules separate those with high mechanical interest and aptitude from those who have low scores in this criterion. In this table the t-value is 2.64 for the one per cent level, and 1.99 at the five per cent level.

The individual tests that differentiated best between the two groups were the Crissey Test (19), Purdue Assembly (16), Stencil Designs (1), Kent-Shakow Form Board (6), and the Wiggly Blocks (8). For all of these tests the t-value was between 6.0 and over 8.0. In all of these tests the subject was asked to assemble a number of pieces into a whole with some spatial restrictions. The most differentiating of these tests was the Crissey Test which required the subject to see the relations between several mechanisms. The least differentiating of these tests were Peg Board (2 and 3), Rate of Manipulation (11 and 12), and Link Dial (20). Inspection of these tests makes it immediately apparent that they feature speed of manipulation and that they represent relatively little mental effort or mechanical understanding. Since most of the tests in this list except the Rate of Manipulation tests are differentiating at the one per cent level or better, our judgments are made here on relative differentiation among tests, most of which differentiate the two criterion groups satisfactorily.

Table 2 shows similar data for the group tests. All of the group tests were in paper-pencil form. The most differentiating among the group tests were Mechanical Movements (14), Surface Development (15), Block Assembly (30), Gottschaldt Figures (8), Block Counting (1), Paper Puzzles (2), and Lozenges A (17).

In this list we find also that the majority of the group tests in paper-pencil form differentiated successfully between the two criterion groups. Here also we are judging the relative values in a large group of tests. Several tests were shown to be definitely not useful in that their differentiation was not satisfactory. These tests were Hands (5), and Jig Saw Pieces (21). The Hands Test (5) may represent a kinesthetic factor, but this factor is also present in Bolts (7) which is differentiating. This may possibly be explained by an experience factor in Bolts (7). Perhaps a better explanation of the difference between the Hands and Bolts tests is that the Hands test called for differentiation of right and left whereas the Bolts test asked the subject to indicate the desired direction of rotation without calling it either right or left. The test Jig Saw Pieces (21) has low differentiating value and this lends support to the inference that mechanical aptitude is not characterized in any essential way by ability to make very fine discriminations in size, shape, and line length. The test Jig Saw Pieces (21) was designed to ascertain whether mechanical aptitude represented the ability to make rather fine discriminations in shape. The indication here seems to be that such an ability is not a major characteristic of mechanical aptitude. Test 21 does not have any significant saturation on any of the factors that are interpreted, and its communality is only .25. The ability to make fine discriminations in curved shapes does not have any appreciable variance in common with the rest of this battery.

Since the group test battery was factorially analyzed, it is of some interest to examine

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2. These tests are described in detail in the following microfilms which are available from the University of Chicago Library microfilm department. Negative No. 1767, Mechanical Aptitude II, Description of Group Tests; Negative No. 1844, Mechanical Aptitude III, Analysis of Group Tests; Negative No. 1845, Mechanical Aptitude IV, Description of Individual Tests.

the factorial composition of tests that were most differentiating. Block Counting does not have any outstanding factorial saturations in the factors that were interpreted. Paper Puzzles had some saturation in the second space factor and in the second closure factor. Gottschaldt Figures (8) showed appreciable saturation in the second closure factor. Mechanical Movements (14) has strong saturation in the second space factor. Surface Development (15) had its highest saturation on the second space factor. Lozenges A (17) had highest saturation in the third space factor. Block Assembly (30) showed its strongest saturation in the third memory factor and some saturation in the second space factor. Inspection of this kind lead to the conclusion that the second space factor is heavily represented in mechanical aptitude and that the second closure factor is also here represented although not so strongly as S_2.

In Tables 3 and 4 we have summarized the differentiating values of personality traits and activity interest with special reference to mechanical aptitude and interest. Table 3 shows the t-values for the seven scores in a temperament schedule.[3] It is not surprising to find that masculinity which is represented by the athletic interests (26) differentiates the two criterion groups quite satisfactorily. Of equal interest is the fact that the score in sociability (31) correlates negatively with mechanical interest. According to these findings, we should conclude that socially outgoing individuals tend to rate lower than average in mechanical aptitude. The same conclusion is supported though less emphatically by considering the three scores, leadership (29), emotional stability (30), and sociability (31). In all three of these scores the criterion group with high mechanical aptitude and interest scored lower than the criterion group which is characterized by low mechanical aptitude and interest. This finding is specially marked for the score in sociability (31). Table 4 shows the t-values for the scores in the Kuder Interest Schedule. In this table we have omitted the score in mechanical interest because that was a part of the criterion by which the two criterion groups were selected. By the construction of the Kuder Schedule, it follows that a high score in one field necessarily implies a correspondingly lower score in other traits. Several of the t-values are of special interest for the present problem. Scientific interests (35) show definite association with mechanical interests, and this is as we should expect. On the other hand, the results show a negative association between mechanical aptitude and musical, literary, persuasive, and computational interests. The negative association seems especially clear for literary and musical interests. It looks, therefore, as if people with mechanical aptitude and interests are not ordinarily found among socially outgoing people or among those with strong literary or musical interests.

These studies indicate pretty clearly that a successful test for mechanical aptitude should feature primarily the second space factor. The second closure factor contributes significantly although it is less important than the space factor S_2. The majority of the group tests in this study differentiated between the two criterion groups with t-values at the one per cent level of significance or better. Hence it may be inferred that the primary abilities which characterize this battery can be used for differentiating individuals with mechanical aptitude. However, there are marked differences among the tests. Some factors are definitely superior for this purpose. These factors are principally the first and second space factor S_1 and S_2, the two closure factors C_1 and C_2, as well as induction I. But it is clear from our tabulations of t-values in relation to the factorial composition of the tests that the second space factor S_2 is definitely the most differentiating for mechanical aptitude.

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3. This temperament schedule has been developed from a longer list of 340 items. The schedule is arranged in carbon scoring form with a profile on the individual answer sheet. It is published by Science Research Associates, Chicago, Illinois.

According to our interpretation the second space factor is the same factor that Guilford has called visualization. Our psychological interpretation of the second space factor is that it represents the ability to think about configurations in which there is internal displacement among the parts. To think about a mechanism in movement requires the second space factor. The same space factor seems to be involved when the subject is thinking about a single piece of material that is being deformed or altered in shape. Tests like surface development and the paper-folding test are examples of this type. It does not seem to be essential, therefore, whether the configuration consists of several distinct pieces that move with respect to each other or a single piece of material that is altered in shape. In both cases the configuration has internal movement among its parts.

The first space factor is similar except that it requires the subject to visualize rigid configurations. The question of movement does not alone differentiate between the first and second space factors. The subject may imagine the movement of the whole object or configuration as when it is displaced in the perceptual field or when it is rotated or turned over. If the configuration is rigid, it seems to involve the first space factor, but if it is subject to internal displacement among the parts, the second space factor is involved. Both of these factors involve visualization, at least in the ordinary sense of that term. The third space factor seems to be characterized by the participation of bodily orientation to the object. However, it seems to be distinct from a factor of kinesthetic imagery which is different from the third space factor. The third space factor seems to be the same as the factor that Guilford has called spatial relations. Guilford's terms, visualization and spatial relations, are descriptive of all three space factors, S_1, S_2, and S_3, but these terms are applicable to all of the space factors. No harm would be done if psychologists were to agree that these terms shall be used technically with restrictions to particular factors. It seems quite likely that the psychological interpretations that can now be written will be revised, perhaps many times, before the nature of each factor is known with some confidence. In the meantime we can only name, denote, and symbolize the primary mental abilities to represent current knowledge.

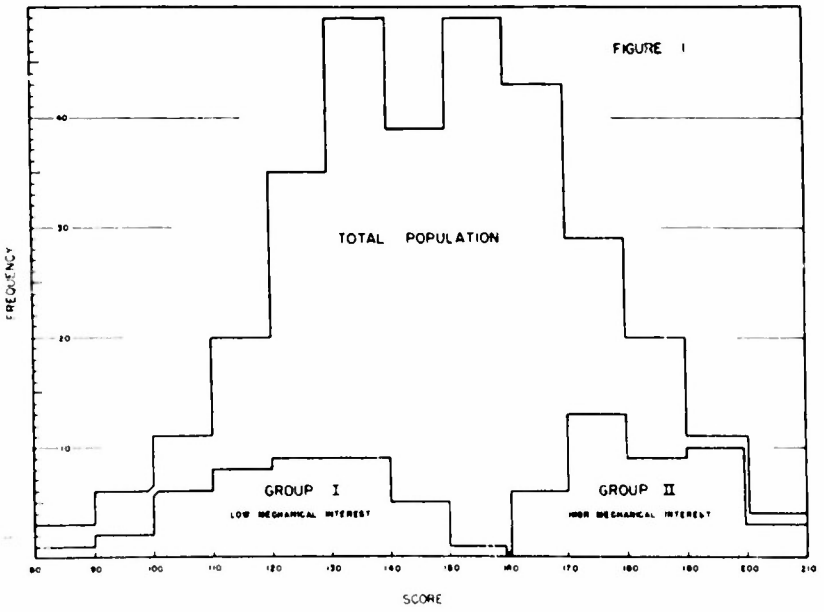

TABLE 1

INDIVIDUAL TESTS

Code No.	Name of Test	No. of Cases		Means		Dispersions		
		N_1	N_2	M_1	M_2	σ_1	σ_2	t
1	Stencil Designs	42	43	35.7	48.2	12.1	6.1	6.0
2	Purdue Pegboard - Insertion	42	43	45.1	45.3	3.54	3.69	.2
3	Purdue Pegboard - Assembly	42	43	20.0	20.9	2.35	1.85	1.7
4	Freeman Puzzle Box	42	43	34.6	48.2	17.9	11.0	4.2
5	Passalong	42	43	58.4	66.1	8.64	14.09	3.0
6	Kent-Shakow Form Board	42	43	43.3	61.1	15.5	6.9	6.7
7	Tweezer Dexterity	42	43	31.2	36.4	9.67	5.78	2.9
8	Wiggly Blocks (trial 1 + trial 2)	42	43	53.3	75.4	19.4	11.7	6.3
9	Wiggly Blocks (trial 1 - trial 2)	42	43	39.5	41.9	19.1	8.8	.7
10	Kohs Blocks	42	43	49.0	75.4	24.0	12.9	6.2
11	Rate of Manipulation (transfer)	42	43	14.1	14.7	5.75	4.59	.5
12	Rate of Manipulation (inversion)	42	43	36.2	35.3	7.74	5.76	.6
13	U-Bolt	42	43	23.2	27.3	8.35	7.12	2.4
14	Form Building	42	43	39.5	47.1	12.5	9.8	3.1
15	Rosenstein Disc	42	43	66.8	80.3	21.4	11.4	3.6
16	Purdue Assembly	42	43	39.7	65.1	15.9	14.9	7.5
17	S. A. M. Complex Coordinator	42	43	37.1	44.0	7.17	7.22	4.4
18	Minnesota Assembly	42	43	47.5	69.8	18.1	11.1	6.7
19	Crissey Test	42	43	31.9	62.8	21.7	10.5	8.2
20	Link Dial	42	43	35.8	36.8	15.5	14.2	.3
21	Yerkes Multiple Choice	42	43	67.7	76.1	21.9	13.4	2.1
22	Engine Lathe (median dist.)	42	43	10.7	14.1	3.40	1.48	5.8
23	Engine Lathe (median time)	42	43	34.2	38.8	9.27	6.57	2.6
24	Crawford - Pins & Collars	42	43	59.1	73.7	19.3	12.3	4.1
25	Crawford - Driving Screws	42	43	41.9	54.4	19.7	13.8	3.4

TABLE 2

GROUP TESTS

Code No.	Name of Tests	No. of Cases		Means		Dispersions		t
		N_1	N_2	M_1	M_2	σ_1	σ_2	
1	Block Counting	41	39	42.0	56.7	11.7	11.1	5.7
2	Paper Puzzles	41	43	9.9	15.5	3.75	5.06	5.7
3	Cards	39	42	29.4	38.4	11.0	10.4	3.7
4	Figures	39	42	31.8	40.0	13.8	11.5	2.9
5	Hands	42	43	29.3	31.0	13.6	13.5	0.6
6	Copying	42	42	14.1	20.5	6.71	7.24	4.1
7	Bolts	41	42	27.3	42.2	17.7	11.7	4.5
8	Gottschaldt Figures	42	42	20.1	32.1	8.80	9.98	5.8
9	Street Pictures	42	43	12.8	14.6	2.82	2.65	3.0
10	Mutilated Words	42	42	12.3	13.4	3.89	3.66	1.3
11	Designs	40	41	22.5	27.1	7.36	6.32	3.0
12	Memory for Pictures	37	42	67.5	71.6	8.08	6.07	2.5
13	Visual Memory	40	42	33.3	36.2	8.93	7.23	1.6
14	Mechanical Movements	38	43	24.2	43.7	9.29	11.88	8.2
15	Surface Development	41	42	21.8	40.6	10.2	11.6	7.8
16	Reversals and Rotations	41	42	22.4	32.0	9.14	11.61	4.1
17	Lozenges A	39	37	12.6	28.6	11.96	15.32	5.0
18	Cubes	39	38	11.1	19.2	7.20	8.07	4.6
19	Identical Forms	42	43	46.6	52.6	7.91	5.74	4.0
20	Mutilated Pictures	41	42	16.1	19.8	3.91	4.85	3.7
21	Jig Saw Pieces	42	42	17.9	19.2	8.50	8.08	0.7
22	Memory for Geometric Designs	39	42	15.4	18.5	5.28	4.19	2.9
23	Picture Squares	39	41	11.0	12.1	3.45	2.84	1.5
24	Letter Series	40	37	14.1	17.8	5.52	4.86	3.1
25	Letter Grouping	41	43	15.9	19.2	4.35	3.01	4.0
26	Figure Analogies	41	40	16.4	19.9	5.28	3.41	3.5
27	Figure Grouping	41	42	18.4	21.7	3.52	2.69	4.8
29	Rotation of Solid Figures	41	39	7.61	9.95	3.05	2.49	3.7
30	Block Assembly	41	43	9.88	15.67	4.38	4.26	6.1
32	Electrical Experience	41	40	35.6	45.1	5.30	6.41	7.2

TABLE 3

THURSTONE TEMPERAMENT SCHEDULE

Code No.	Name of Variable		No. of Cases N_1	N_2	Means M_1	M_2	Dispersions σ_1	σ_2	t
26	Athletic	At	42	43	11.1	12.7	3.18	2.62	2.5
27	Active	Ac	42	43	8.60	9.81	2.89	3.25	1.8
28	Impulsive	I	42	43	11.1	11.5	3.28	2.57	0.5
29	Leadership	L	42	43	7.64	7.23	3.60	3.84	0.5#
30	Emotionally Stable	St	42	43	9.60	9.30	3.14	3.24	0.4#
31	Sociable	So	42	43	10.2	8.9	2.70	2.33	2.4#
32	Reflective	R	42	43	6.07	6.86	2.72	2.85	1.3

In these variables, Leadership, Sociability, and Emotional Stability, group I rated higher than group II.

TABLE 4

KUDER INTEREST SCHEDULE

Code No.	Name of Variable	No. of Cases N_1	N_2	Means M_1	M_2	Dispersions σ_1	σ_2	t
34	Computational interests	42	42	33.3	30.0	8.62	7.50	1.9#
35	Scientific interests	42	42	66.5	75.0	14.5	11.5	2.9
36	Persuasive interests	42	42	65.2	59.9	11.7	10.1	2.2#
37	Artistic interests	42	42	51.0	56.6	13.8	13.0	1.9
38	Literary interests	42	42	48.7	41.2	12.1	10.0	3.0#
39	Musical interests	42	42	23.3	16.2	10.1	8.8	3.4#
40	Social Service interests	42	42	64.2	61.0	13.1	14.4	1.1#
41	Clerical interests	42	42	51.9	45.9	11.2	9.2	2.6

In several traits, group I rated higher than group II. These were Computational, Persuasive, Literary, Musical, and Social Service interests.

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